GARNET, INDUSTRIAL

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Domestic survey data and table were prepared by Connie Lopez, statistical assistant.

In 2013, U.S. production of crude garnet concentrate for industrial use was estimated to be 33,900 metric tons (t) valued at about $5.76 million, a decrease from 46,900 t valued at about $8.60 million in 2012. U.S. exports and imports of industrial garnet were estimated to be 14,400 t and 148,000 t, respectively. U.S. apparent consumption was estimated to be 167,000 t.

World production of crude garnet concentrate for industrial use was estimated to be 1.66 million metric tons (Mt) during 2013, compared with 1.67 Mt in 2012 (table 1).

This report includes information on garnet produced in the United States that was used for industrial purposes. Current information on gem-grade garnet can be found in the Gemstones chapter of the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using unrounded data.

Garnet has many industrial applications because of its angular fractures, relatively high hardness and specific gravity, chemical inertness, nontoxicity, lack of crystalline silica, and its ability to be recycled.

Garnet is the general name given to a group of complex silicate minerals, all with isometric crystal structure and similar properties and chemical composition. The general chemical formula for the garnet minerals is \(A_2B_2(SiO_4)_3\), where A can be calcium, ferrous iron, magnesium, or manganese, and B can be aluminum, chromium, ferric iron, or rarely, titanium. The most common garnet minerals are classified into three groups—the aluminum-garnet group, the chromium-garnet group, and the iron-garnet group. The most common minerals of the aluminum-garnet group are almandine or almandite, grossularite, pyrope, and spessartite. Uvarovite is the most common chromium garnet, and andradite is the most common iron-garnet mineral.

Garnet occurs worldwide in many rock types, principally gneisses and schists; other sources include contact metamorphic rocks, metamorphosed crystalline limestones, pegmatites, and serpentinites. Alluvial garnet is associated with heavy-mineral sand and gravel deposits in many parts of the world. Occurrences of garnet are numerous; however, relatively few commercially viable garnet deposits have been identified.

Production

The U.S. industrial garnet industry is dominated by a few major producers. The garnet industry has encountered progressively higher production costs and tighter profit margins since the mid-1990s. These factors have resulted in the loss of noncompetitive producers. Because of the need to keep production costs at a minimum, the most competitive producers are those who produce garnet in combination with one or two other minerals, have reserves that can be mined at a low cost, and have the ability to react rapidly to changes in market demand. The value of industrial garnet is influenced by the size and grade of reserves, the type and quality of garnet mined, the proximity of deposits to infrastructure and consumers, and the milling costs. Most of the industrial-grade garnet mined in the United States is almandine (iron-aluminum silicate) and pyrope (magnesium-aluminum silicate); some andradite (calcium-iron silicate) also is mined domestically. Industrial garnet is produced from alluvial bar and beach deposits, such as those in Idaho and Montana (also those in Australia and India), and it is produced from hard rock deposits, such as those in New York (Moore, 2006).

Three U.S. companies accounted for all domestic production—one in Idaho and two in New York. The USGS obtained the data in this report through a survey of U.S. industrial garnet producers. Production amounts and values for any nonreporting companies were estimated based on industry production trends, reports from some producers and other industry sources, and discussions with consultants within the garnet industry.

In 2013, U.S. production of crude garnet concentrate for industrial use was estimated to be 33,900 t valued at about $5.76 million (table 1). This was a 28% decrease in production quantity and a decrease of 33% in value compared with 46,900 t valued at $8.60 million in 2012. The United States accounted for about 3% of global industrial garnet production. Refined garnet material produced during 2013 was estimated to be 32,600 t valued at $9.30 million with a unit value of $286 per metric ton, which was a 26% increase in quantity, an increase of about 31% in value, and a 4% increase in unit value compared with 2012 levels. Garnet producers in 2013 were Barton Mines Corp. in Warren County, NY; Emerald Creek Garnet Ltd. in Benewah County, ID; and NYCO Minerals, Inc. in Essex County, NY. Barton International, the first and oldest industrial garnet mining operation in the world, also is the oldest continuous mining operation in New York and the second oldest continuous mining operation under continuous ownership in the United States. The company’s Gore Mountain Mine began producing industrial garnet as the primary product in 1878 and continued to operate throughout 2013 (Lake George Guide, undated). In addition to these producers, Opta Minerals Inc. in Clinton County, NY, processed and sold all the crude garnet mined by NYCO Minerals as a byproduct of wollastonite production in 2013. Opta Minerals also operated Emerald Creek Garnet through its subsidiary, WGI Heavy Minerals, Inc. (Opta Minerals Inc., 2012; Patel, 2012).

A mining operation under development in Coos County, OR, by Oregon Resources Corp. was expected to produce alluvial sands containing chromite, spessartite garnet, and other minerals. During the last quarter of 2012, a test run of garnet production was expected, but the garnet operation was placed in care-and-maintenance status, which continued in 2013. When the garnet production is brought online, the garnet is expected to be used for industrial purposes.
executive officer, Oregon Resources Corp., oral commun., July 30, 2012; May 8, 2013; written commun., April 27, 2015). Oregon Resources estimated that the mine would be able to produce 635,000 tons per year (t/yr) of ore, yielding 54,400 t/yr of chromite and 16,300 to 18,100 t/yr of spessartite garnet. The company projected a 15-year mine life for the operation (James Dingman, retired director of marketing and sales, Oregon Resources Corp., written commun., February 28, 2007; oral commun., July 27, 2012).

Burrell Western Resources announced the discovery of a large deposit of garnet between Alamogordo, NM, and El Paso, TX, in the Jarilla Mountains Mineral District of Otero County, NM. In November 2013, Burrell Western Resources filed an exploratory drilling application with the U.S. Bureau of Land Management that stated that, based on preliminary drilling and testing, the deposit could contain as much as 2.5Mt of mineable material. Using a conservative market value for garnet, Burrell Western Resources estimated that the deposit could contain as much as $1 billion worth of garnet. Burrell Western Resources planned to eventually mine the garnet and likely would process it in nearby Anthony, NM, for distribution (Scott, 2013).

Consumption

In 2013, the estimated U.S. apparent consumption of industrial garnet was 167,000 t (table 1). The United States accounted for about 10% of global industrial garnet use.

The end uses for garnet in the United States and their estimated market share in 2013 were abrasive grains for waterjet cutting, 35%; abrasive blasting media, 30%; water filtration, 20%; abrasive powders, 10%; and other, 5%. Domestic industries that consume garnet include aircraft and motor vehicle manufacturers, ceramics and glass producers, electronic component manufacturers, filtration plants, glass polishing, the petroleum industry, shipbuilders, textile stonewashing, and wood-furniture-finishing operations.

Most industrial garnet is used as an abrasive because of its hardness, which ranges from 6 to 7.5 on the Mohs scale. High-quality, high-value garnet grain has been used principally for such applications as optical lens grinding and plate-glass grinding for more than a century; industrial diamond and fused aluminum oxide are competitors in these applications. In recent years, industrial garnet powders have been used for high-quality, scratch-free lapping of semiconductor materials and other metals. Garnet is a good alternative to silica sand as a natural abrasive blasting medium because garnet does not have the health risks associated with the inhalation of airborne crystalline silica dust, and it is a safer abrasive for the environment (Lismore, 2013). Garnet has replaced some silica sand in the abrasive blasting media market. At present, however, silica sand and mineral slag continue to be the most widely used media in blasting. The U.S. petroleum industry is one of the leading garnet-consuming industries, using garnet for cleaning drill pipes and well casings.

The oil and gas drilling industry has started using garnet as an oil and gas reservoir fracturing proppant, alone or mixed with other proppants. In August 2012, Preferred Sands, LLC, one of North America’s leading hydraulic fracturing sand and coated proppant manufacturers, introduced a nonphenolic resin-coated garnet proppant that can consistently create particle-to-particle bonding in conditions as low as 32 °C (90 °F) without the use of an activator. This proprietary technology was developed by Preferred Sands in conjunction with The Dow Chemical Co. The new proppant, RCS Garnet®, can be used in low-temperature well environments, such as those found in Alberta, Canada, and in the Permian Basin in Texas. RCS Garnet® is an alternative to commonly used phenolic products, which were designed for use in high-temperature environments and require an activator to create the particle-to-particle bonding necessary for flowback control in low-temperature wells. Using an activator adds cost and risk of contamination. RCS Garnet® was designed to create particle-to-particle bonding between 32 °C (90 °F) and 93 °C (200 °F) without the use of an activator. The product was launched and went into full production in February 2013. RCS Garnet® minimizes chemical leaching, reduces environmental impacts, and improves performance and sustainability (PR Newswire, 2012; Dow Chemical Co., 2013).

The aircraft manufacturing and shipbuilding industries use garnet for blast cleaning and for finishing metal surfaces. Similar uses include the cleaning and conditioning of aluminum and other soft metals, as well as metal cleaning by structural steel fabrication shops. Garnet entrained in high-pressure streams of water also is used to cut many different materials. Garnet powders generally are used for antiskid surfaces, antislip paints, and glass and ceramic polishes.

Waterjet cutting is the process of combining water under ultrahigh pressure with entrained garnet grains to cut a wide variety of materials. Materials cut using this process range from soft leather and fabric to hard steel, titanium, and other metals. Waterjet cutting makes it possible to carve extremely complex shapes with computer-assisted cutter control. Almandine-pyrope garnet is excellent for this application because it strikes the necessary balance between cutting productivity and equipment wear. The waterjet market began to develop slowly in the late 1980s and early 1990s, and it has grown at a faster rate in the past 20 years. Future growth is expected to remain steady as use of this technology expands in existing areas and enters new applications. Abrasive waterjet cutting provides a tool for manufacturers faced with the task of cutting new materials, such as composites and sandwiched materials that had been problematic to machine in the past. Waterjet cutting allows for flexibility and eliminates the need for flame cutting. Cutting fragile materials or intricate patterns by abrasive waterjet cutting significantly decreases the amount of distortion and breakage (Rapple, 2006).

Low-quality industrial garnet, which has lower hardness and is more highly fractured, is used as a high-density medium in water filtration systems because of its relative inertness and resistance to chemical degradation. Garnet is well suited for water filtration and treatment because it is relatively heavy and chemically stable. Mixed-media water filtration, which uses a mixture of anthracite, garnet, and silica sand, has displaced older filtration methods because it provides better water quality. Garnet competes with ilmenite, magnetite, plastics, and silica sand as a filtration medium.

Other applications for garnet include the manufacture of coated abrasives and the finishing of felt, hard rubber, leather,
plastics, and wood. In the coated-abrasive market, garnet falls between low-cost quartz sand or staurolite and more costly manufactured abrasives, such as fused aluminum oxide and silicon carbide. Garnet is more efficient than quartz sand in most coated-abrasive applications. Owing to its friable nature and lower hardness, garnet cannot compete with manufactured abrasives in metalworking applications that require substantial metal removal.

Other natural and manufactured abrasives can substitute to some extent for all major end uses of garnet. In many cases, however, the substitutes would entail sacrifices in quality or cost. Fused aluminum oxide and staurolite compete with garnet as a sandblasting material. Diamond, corundum, and fused aluminum oxide compete for lens grinding and for many lapping operations. Emery is a substitute in nonskid surfaces. Quartz sand, silicon carbide, and fused aluminum oxide compete for the finishing of plastics, wood furniture, and other products.

U.S. industrial garnet apparent consumption increased steadily between 2009 and 2012, when levels seen prior to the global recession were exceeded. During 2013, U.S. industrial garnet apparent consumption decreased by 16% compared with that in 2012 (table 1). Garnet materials most preferred for waterjet cutting applications remain in tight supply.

**Prices**

Industrial garnet pricing varies over a wide range, depending on application, quality, quantity purchased, source, and type. During 2013, domestic unit values for crude concentrates for different applications ranged from about $150 to $175 per metric ton, with an average for the year of $170 per ton. Domestic unit values for refined garnet for different applications sold during the year ranged from $275 to $300 per ton, with an average for the year of $285 per ton.

The estimated average unit values of garnet from other leading producers around the world based on the customs value of import shipments were as follows: Australia, $202 per ton; Canada, $286 per ton; China, $435 per ton; and India, $214 per ton. During 2013, the average value of industrial garnet imported from all sources was $230 per ton of crude garnet, which was an 11% increase from $208 per ton in 2012.

**Foreign Trade**

Lower priced foreign imports of garnet slowly began displacing U.S. production in domestic markets during the 1990s. For the past 5 years, industrial garnet imports have provided between 60% and 81% of the total U.S. industrial garnet supply.

The U.S. Census Bureau compiles trade data on exports and imports of industrial garnet mixed with other natural abrasive commodities, such as emery and corundum, so the data cannot be identified specifically as garnet. Exports and imports of industrial garnet for 2013 were estimated to be 14,400 t and 148,000 t, respectively. These estimates were based on reports from some producers and other industry sources, and discussions with garnet industry consultants. Exports decreased slightly from those of 2012, and imports decreased by about 11% compared with those of 2012. In 2013, Australia, China, and India continued to supply the majority of the U.S. garnet imports for consumption, with Australia providing 48%; India, 42%; China, 9%; and other countries, 1%. About 80% of garnet exports from the United States went to Canada, China, Germany, Japan, Mexico, South Africa, Suriname, Switzerland, Taiwan, Trinidad and Tobago, and Venezuela.

**World Review**

The USGS estimated total 2013 world industrial garnet production to be about 1.66 Mt, a slight decrease compared with that in 2012. In 2013, India, China, Australia, and the United States were, in decreasing order of tonnage, the leading producers. In 2013, India produced about 47% of total global output; China, about 30%; Australia, 15%; the United States, about 3%; and other countries, about 5%. China and India are expected to continue as the leading world producers of industrial garnet. Russia and Turkey have been mining garnet in recent years, primarily for domestic markets. Small garnet-mining operations also are located in Canada, Chile, the Czech Republic, Pakistan, South Africa, Spain, Thailand, and Ukraine. Production in most of these countries is for domestic use. Industrial garnet suppliers in Australia and India continued to be negatively affected by stronger domestic currencies against the U.S. dollar and increased production costs. This allowed supply replacement from sources in China. The supply of industrial garnet in China was increasing, but the quality of those supplies has not been as consistent as other producers (Industrial Minerals, 2011).

China and India were expected to steadily increase garnet output for the next decade and have become significant garnet sources for other countries. Worldwide end uses and their estimated market shares were abrasive blasting media, 50%; abrasive grains for waterjet cutting, 30%; water filtration, 15%; and other end uses, 5%.

**Outlook**

The U.S. garnet industry has encountered higher production costs and tighter profit margins during recent years. The industry also has been competing with lower priced foreign imports that have displaced U.S. production in domestic markets, which has resulted in the closure of noncompetitive operations. Garnet will continue displacing silica sand for blasting as countries ban the use of silica sand blasting media owing to its associated occupational health risks. Garnet also will continue displacing mineral slag abrasives for blasting because it is safer for the environment and less costly to dispose of after it has been recycled (Lismore, 2013).

Worldwide demand for industrial garnet is expected to continue to increase, especially within the markets for abrasive grains for waterjet cutting and for abrasive blasting media. Garnet demand also is expected to continue to expand for aircraft manufacturing and shipbuilding, where significant quantities of garnet are used for abrasive blast cleaning and finishing of metal surfaces and for waterjet cutting. The use of garnet in waterjet cutting is expected to increase at a higher rate than the use of garnet as an abrasive blasting media.
References Cited


GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications


Garnet (Industrial). Ch. in Mineral Commodity Summaries, annual.


Other


Industrial Minerals, monthly.

Industrial Minerals Prices and Data, annual.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>ESTIMATED SALIENT U.S. INDUSTRIAL GARNET STATISTICS 1</th>
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1Revised.

2Domestic production plus imports minus exports.

1Data are rounded to no more than three significant digits.